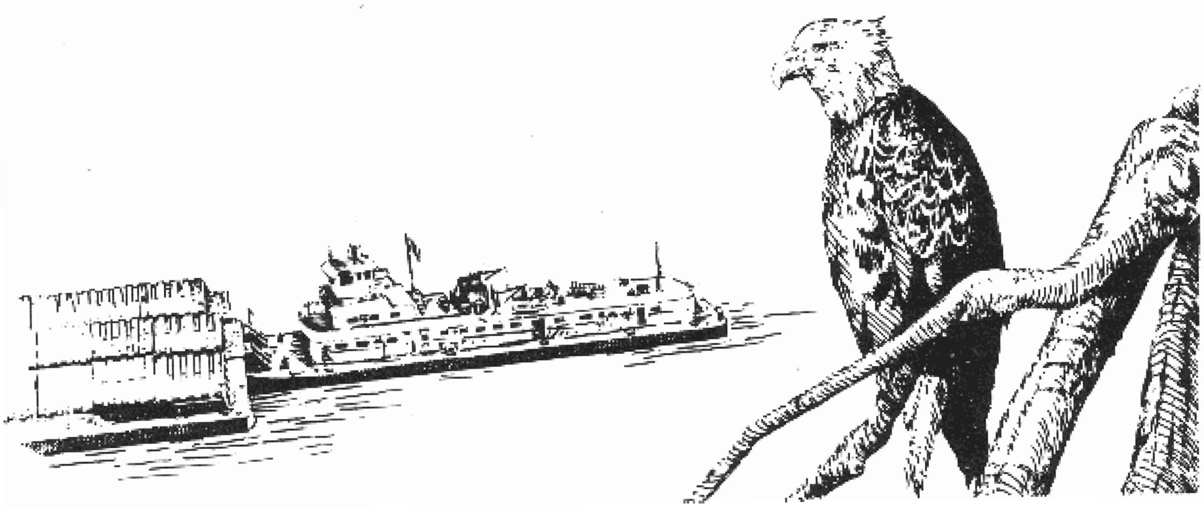
# Chapter 4

# Stopping the Leaks: the 4½-Foot Channel



When Major Francis U. Farquhar became District Engineer on November 15, 1877, the Rack Island District was firmly established as a force on the Upper Mississippi River. The period of experimentation and isolated projects was coming to an end. The Des Moines Rapids Canal had just opened, the Rock Island Rapids were navigable, and the experiments with wing dams and dredging had proved their point.

There were still critics who talked about "Humphrey and his corpse of engineers,"[1] but all dong the river the Corps was growing up. The controversial Eads Jetties at South Pass had been authorized on March 3, 1875. 'The ship channel. which they had scoured to the Gulf of Mexico had once again made water shipment to New York competitive with the railroads. By 1878 the jetties had proved themselves, increasing the demand for further improvement d the channel up to St. Paul.

River improvement conventions which had grown to be a popular means of applying pressure to Congress before the Civil War now increased in number and voice, all requesting far more extensive channel improvement. Conventions met at St. Louis in 1867, 1872, 1873; at New Orleans in 1869, 1876; at St. Paul in 1875, 1877; at Prairie du Chien in 1868. Even after passage of the 4½-foot channel project conventions continued to keep the pressure on and the appropriations coming.

District Engineer Colonel Alexander Mackenzie attended one of these conventions at St. Louis in 1881, shorty after the improvement work had begun. The members were interested in exactly what the Corps intended to do, and how fast, but Mackenzie, after answering a few brief questions, asked to be excused "inasmuch a3 I would greatly prefer, as heretofore, to carry on the practical work, than to appear as a public speaker."[2] Privacy, however, was a luxury that Rock Island District Engineers were increasingly forbidden. As District activities became more complex, public relations became an inevitable part of a District Engineer's responsibilities.

The Act of June 18, 1878, authorized a 4½-foot low water channel from St. Paul to St. Louis, to be accomplished by contraction of the channel through wing and dosing dams. Eventually, this was to be increased to 6 feet. The Act appropriated $250,000 for improving the channel from St. Paul to the Des Moines Rapids, and $100,000 for channel improvement from the rapids to the mouth of the Ohio River.

The 4½-foot channel project caused a change in the method of operations in the District from many scattered duties to one unified project, When Major Farquhar became Rock Island District Engineer he assumed command of 17 separate river improvement projects ranging as far as the Red River of the North, On July 15, following passage of the 4½-foot channel, Farquhar was relieved of all improvement work above St. Paul. Even operation of the Des Moines Rapids Canal wa3 placed under the separate command of Major Amos Stickney. The 4½-foot channel became the single most important reason for the Rock Island District's existence.[3]

Preparation for channel improvement was begun even before Congress authorized the project. During the winter of 1877-78, Farquhar had a general map of the Mississippi River drawn up. The map covered the river from the Falls of St. Anthony to the mouth of the Illinois River, and was a composite of all previous maps and surveys in the Rock Island Office. The map was photolithographed in 26 sheets and distributed to rivermen with the hope khat it would induce a more uniform nomenclature of localities, a needed step for river improvement.

After the 4½-foot project was passed, the first action wa3 to make yet another survey of the river. The survey made by Meigs in 1874 had only gotten a3 far as La Crosse. In 1875 C.W. Durham had continued Meigs' survey to Keokuk, but no thorough survey had been made south of the Des Moines Rapids. Even the sections of the river that had been surveyed had changed so much in four years that the Meigs and Durham surveys were useless,

Consequently, the first comprehensive survey of the Mississippi from St, Paul to Grafton, Illinois;, was begun under Farquhar during the 1873 season, and finished in the fall of 1879. Seven separate survey partiss were assigned sections of the river. Each party consisted of 24 men: two assistant engineers, one pilot, three recorders, one clerk, a transit party of six, a level party of four, a sounding party of five, and laborers to build sounding stadons. Equipment for each party included a 34- by 8-foot steam launch, a 40- by 10-foot quarterboat {used as a cookhouse and office), three rowboats, and five 12- by 12-foot tents. The whole camp moved 8 to 12 miles at a time.

The map prepared from this survey was published in 83 sheets, and excluded only the Rock Ishnd and Des Moines Rapids.

Major Farquhar also continued the practice begun by Macomb of dividing the District up into sub-sections (called “districts” or “divisions” in District correspondence). Farquhar placed an assistant engineer in charge of each sub-district. By June of 1879 when Mackenzie arrived as District Engineer, there were five of these sub-sections. This practice allowed each Engineer to become familiar with the peculiar problems encountered on his stretch of river — an important asset, considering the short tours of duty of District Engineers. These assistants got to know the contractors and other citizens in their area, and helped make the work of the Corps more personal.

Preparations were made during 1878 for expansion of the District fleet of hats. The *Montana* which had served the District for 14 years was condemned at the end of the 1878 season, and her machinery transferred to a new hull at the D.S. Barmore shipyards at Jefferson, Indiana. The new snagboat which this produced, the *General Barnard*, became past of a growing fleet of steamboats owned and operated by, and in many cases designed and built by, the Rock Island District. At its height in 1910 the District fleet made up nearly 20 percent of the total number of steamboats operating on the Upper Mississippi.

Under Farquhar's direction, engineers in the District began to develop improved equipment. The old chisel boats with their ponderous machinery had never been very efficient, being able to break an average of only 10 cubic yards of rock per day. In September of 1878 Farquhar designed and built a new steam drill scow for subaqueous blasting, hoping to improve on the performance of the chisel boats. The steam drill was built on a decked flatboat furnished with three spuds, and head and side lines. On this deck was placed an upright boiler 57 by 42 inches, which was uaad to power a 4-inch Ingersoll drill. The drill was attached to the boat's cross head, and hinged so that it could be inclined at any angle.

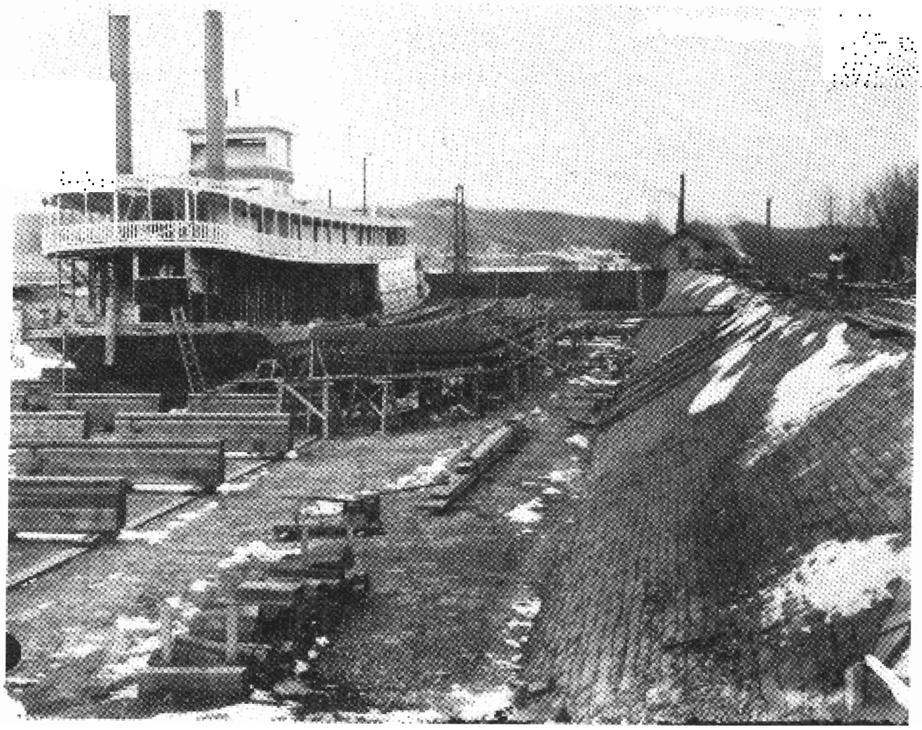
In October the new steam drill and an old chisel boat were towed up to the Moline Chain on the Rock Ishnd Rapids and tested side by side fur 45 days. The steam drill and blasting operation broke an average of 17 cubic yards of rock per day, seven more than the chisel boat. The chisel boat had cost $4,500 to build, while the steam drill boat had cost only $1,800.

Shortly after Mackenzie's arrival to replace Farquhar, District operations were expanded in a new direction with the construction of a Government dry dock at the Des Moines Rapids Canal. The Des Moines Rapids Canal Dry Dock and Canal Shops was the idea of Montgomery Meigs, whose first love was boats. Meigs was responsible for the Mea, design, construction, and operation of these facilities, which were built alongside the canal.

Meigs convinced Mackenzie to submit the dry dock project to the Chief of Engineers in 1882. Such a repair facility was badly needed; no other dry dock existed anywhere on the Upper Mississippi. Whenever a boat of the growing District fleet needed w-pair or re-building, it had to be dragged onto ways on shore. The project was approved in February 1883, and by April Meigs wa3 supervising construction. The dry dock was built at a cost of $133,000 (under five separate appropriations) and finished in 1889. As had been the case with the last few years of construction on the Canal itself, the work was done by hired labor. Meigs never approved of contract work and was always handy with statistics to show how much more cheaply the Corps could do it3 own work.

The dry dock was situated on a piece of low ground on the river side of the canal embankment just above the middle lock. It furnished a basin 400 feet long and 100 feat wide, with entrance from the canal though gates giving an 80-foot opening. The outer embankment of the dry dock was of *clay* covered by rip rap. The new canal shops, including machine and storage sheds. for boat building and repair, were placed at the lower end of the dock.

The dry dock was filled and emptied by culverts opening into both the river and the canal, and fixed up with closing valves. The inlet was at the head and the outlet was at the foot of the pit. Up to a water stage of about 6 feet above low water, the dry dock could be drained directly into the river; at between a 6- and 12-foot water stage, drainage was into the canal. Stages above 12 feet required the assistance of a 12-inch rotary pump.



The Rock Island District steamboat *Coal Bluff* on the ways at the Des Moines Rapids Canal Dry Dock. Since this was the only dry dock on the Upper Mississippi, the District leased it as needed to private companies for repairs.

Because the Government dry dock was the only one on the Upper Mississippi, the District established a policy that welcomed private boats in for repairs when District boats were not using it. The rates charged ran from $15 per day for boats of under 200 tons to $25 per day for boats over 500 tons.

The dry dock was flooded out in 1913 by the same power dam, that submerged the canal. The power company built a new dry dock alongside the new lock near the dam.

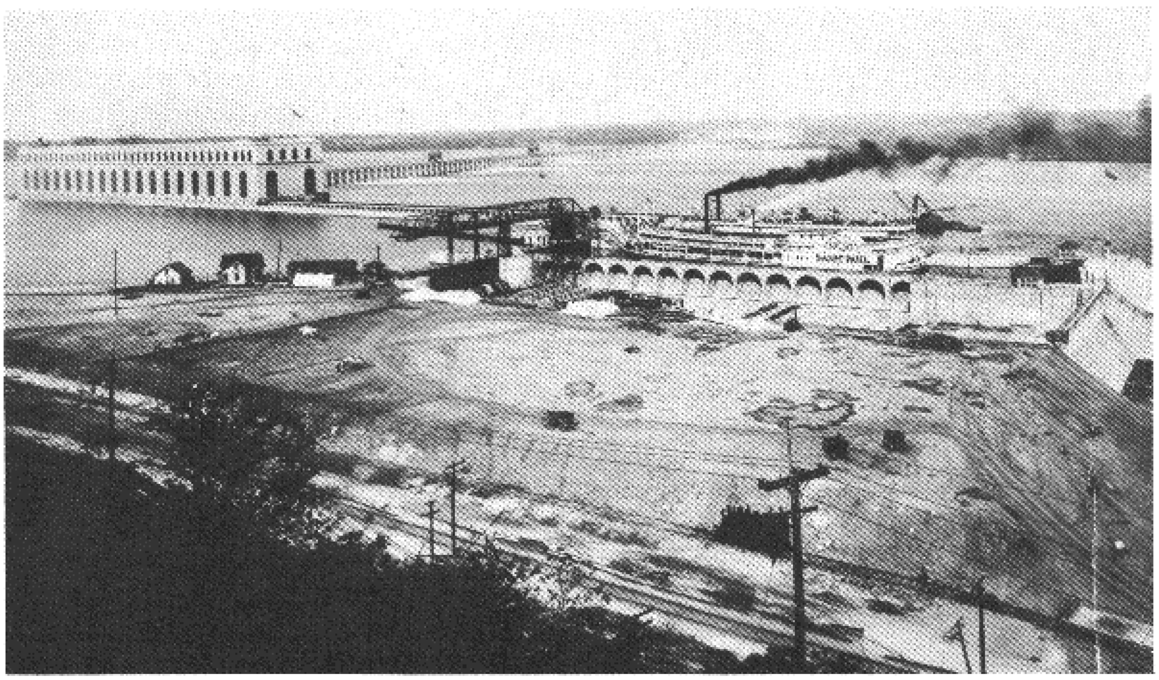
With preliminary plans and preparations made, Mackenzie turned to supervise the first concentrated effort at channel improvement using wing dams. The experiments with wing darns at Pig's Eye Island and other locations in 1873 had proved so successful that the *Montana* had spent a part of each season since then in similar work. During the 1874 season, however, work began in earnest. Several thousand feet of wing and closing dams were built at eight locations. Most of this work survived the flood the following spring which brought the highest water ever known to the Upper Mississippi to that dab.

Wing dams were not new on the Upper Mississippi. Rivermen had long been pleading for wing dams as a means of improving the channel because of the success lumbermen had with variations of these dams. Often during low water, raftsmen had built crude brush dams held in place by stakes to help wash out a bar, but these in turn washed out with the next high water. A more complicated method of scouring a deep channel was developed by early raftsmen on the Chippewa and Wisconsin Rivers. An assistant engineer, J.D. DuShane, explained this method in an 1895 letter:

> The practice was to separate a raft into strings, then float two strings down to a shoal place, sticking one string on one side of the river and one on the other a sufficient distance apart and in funnel shape, the smaller opening being down stream, thus directing a greater volume of water into the narrow opening and producing a scour at and below the opening; then the other string would be floated down, extending below those first stuck, until a cut through the bar was made. The rafts above would then be sent through in pieces, and the parts stuck on the bar forming the shear [sic.] dams would be separated into cribs, which would be hauled into deeper water and sent through the newly made channel and re-rafted below.[4]

Wing dams had been used on the Ohio and Illinois Rivers to deepen the channels. While these were

The Keokuk and Hamilton Water Power Company Dam and Lock completed in 1913. The pool created by this dam flooded out the Des Moines Rapids and the canal. The old canal lies under fifty feet of fill (foreground) but the dry dock can be seen still operating adjacent to the new lock.



more sturdy than the raftsmen's makeshift dams, they seldom lasted more than several seasons before deteriorating. Later wing dam experiments on the Missouri River proved equally transitory. Only in Europe, on the Danube and the Upper Rhine, had wing dams worked as a lasting improvement. Both of these rivers, like the Mississippi, had shifting, sandy bottoms. Wing dams built in the Rock Island District were almost identical in construction to those of the European rivers.[5]

Wing dams worked by constricting the flow of the river especially in low water, forcing the available water into one narrow channel, increasing the current and volume of water and helping to scour the bottom. In the words of the rivermen, wing dams "stopped the leaks."

Shoal water and sandbars were problems all along the Upper Mississippi, but they provided the most difficulty from La Crosse north to St. Paul. From the mouth of the Wisconsin River to the Rock Island Rapids, the 1878 survey showed only 25 bars; between Keokuk and the mouth of the Illinois River there were only 38 bars; but in the short stretch between St. Paul and the mouth of the St. Croix, the worst part of the river, nearly every one of the 25 crossings had shoal water of three feet or less. Along this 28.7 miles of river there were 29 bad sandbars. The whole section from Read's Landing (at the foot of Lake Pepin) to La Crosse was clogged with sand from the Chippewa River and contained 46 bars needing improvement. During many seasons the upper limit of navigation in low water had been La Crosse or Winona.

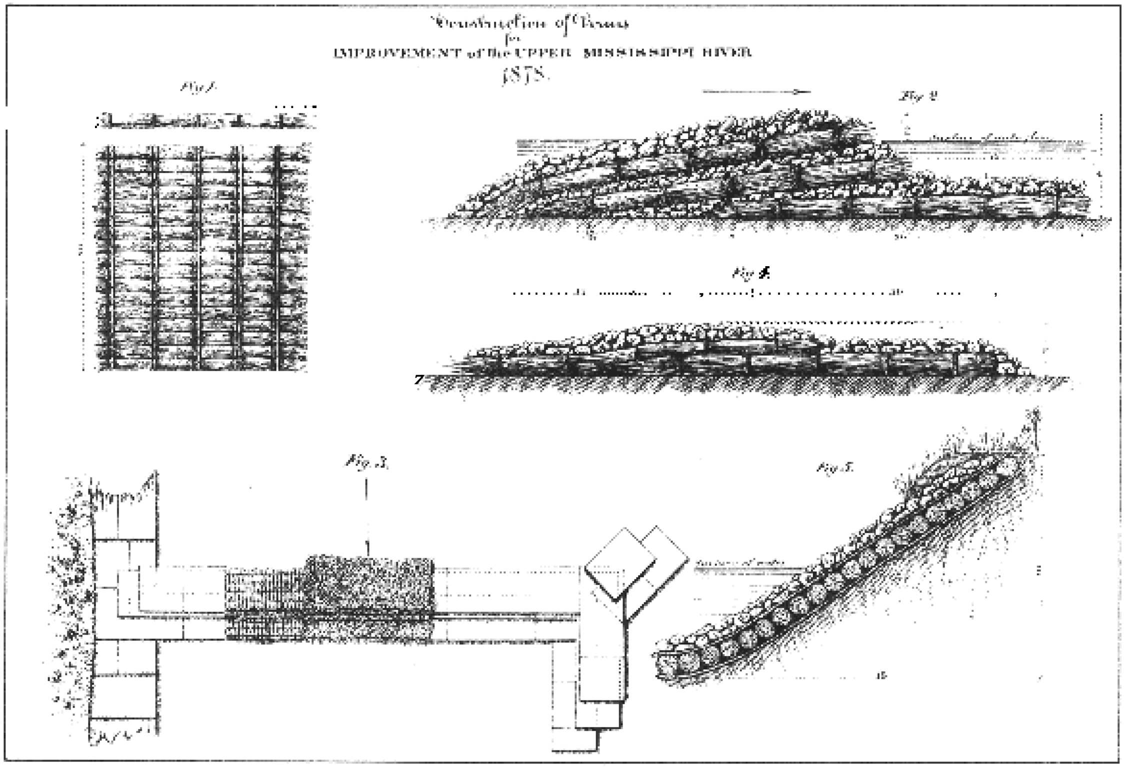
Wing dams worked by constricting the channel. The natural width of the Upper Mississippi varied from 350 feet to 1,400 feet at the mouth of the Missouri River. The wing dams created a channel that was 1,200 feet wide or less. Each section of the river was constricted to the width necessary to produce 4½ feet of water. The dams were built to 4 feet above the low water mark. During high water, when extra scouring was not needed, extra water flowed over the tops of the dams. During low water, however, the current was confined to the narrower channel made by the dams. This increased the velocity of the water, causing the current to stir up and carry out of the channel the sand bottom until the new channel had attained the same area cross section as the wider natural channel. Wide and shallow became narrow and deep. When equilibrium was reached in this new deeper channel, the scouring action stopped. Wing dams were also used to aim the current in a given direction so as to wash away an unwanted bar or aand island.

The Rock Island District Engineers never adopted a formal comprehensive plan for the 4½-foot project. Not until 1897 when District Engineer Colonel W.R. King drew up a provisional plan for the project was there anything but a year-to-year operation. In the 1880 *Annual Report* Mackenzie replied to Congressmen who had criticized this lack of planning:

> A general plan with estimates has been prepared, but it is liable to so many alterations of detail due to changes of the river and experience gains as the work progresses, that it is deemed more proper to simply present objects from year to year for the work which can be accomplished with the amounts then available, selecting for improvement the points known to be most troublesome.[7]

Other critics complained that the practice of small annual Congressional appropriations kept the work at a slow pace, but the District was comfortable with this. Moving slowly gave the river herself a chance to participate in the work. The natural scouring of the river could have been hurried by dredging, but it was more economical to let the river do it, In addition, each new wing dam created new water conditions downstream. It took time for these to develop and show what they were going to do. only then could additional improvements be planned.

One interesting discovery made by Engineers as the work of river improvement continued was that not all of the channel obstruction was natural. DuShane, the assistant engineer at the St. Pad Office of the Rock Island District, discovered that in all of the improvements made above Lake Pepin, the bars removed were found to be "largely composed




Sketches of wing dam construction showing the alternate layers of willow mattress and rock tilting upstream. Bank revetment (Fig. 5) was constructed of the same materials. Much of this construction is still solid after more than 100 years.

of sawdust"[8] and other sawmill refuse which had been dumped in the river. Sawdust was found in bars as far south as Winona.

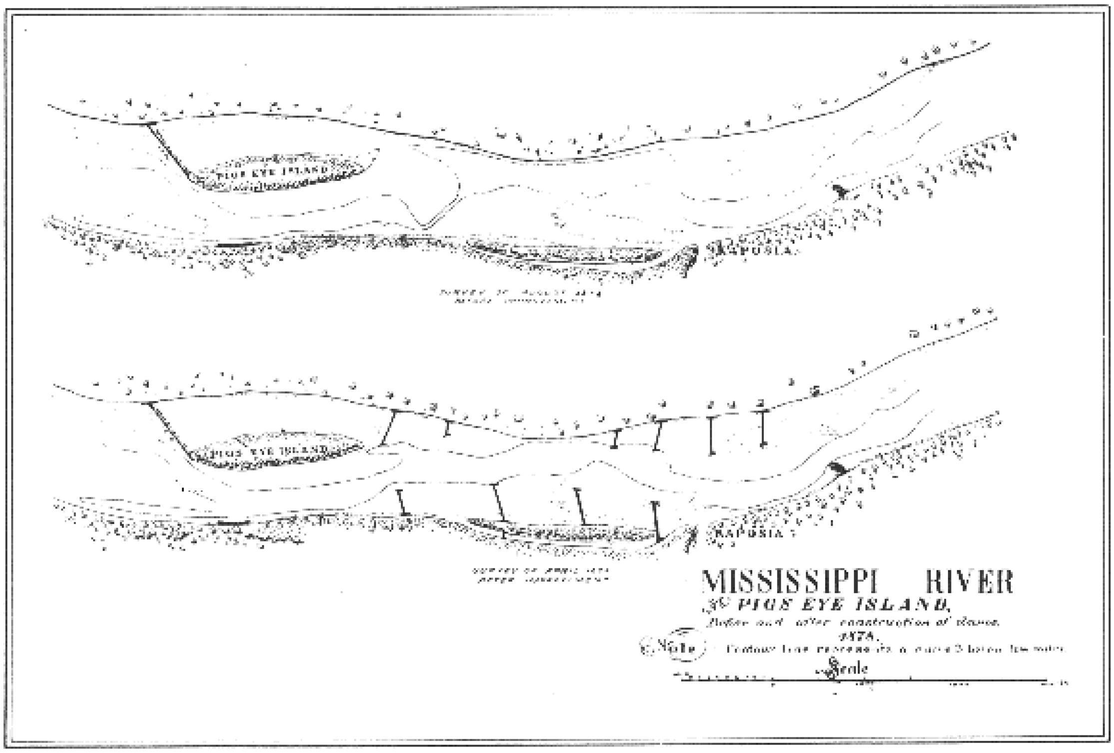
In 1888 the Engineers were called to remove a bar forming near the St. Paul waterfront. Dredging discovered that this bar was formed entirely of garbage dumped into the river by St. Paul. This area of the river had been shoaling for several years; the Corps was called in only when the smell became so objectionable that private citizens obtained an injunction against the governments of both Minneapolis and St. Paul. Minneapolis dumped 500 tons of garbage a day just below the Falls of St. Anthony, and St. Paul added even more than that.

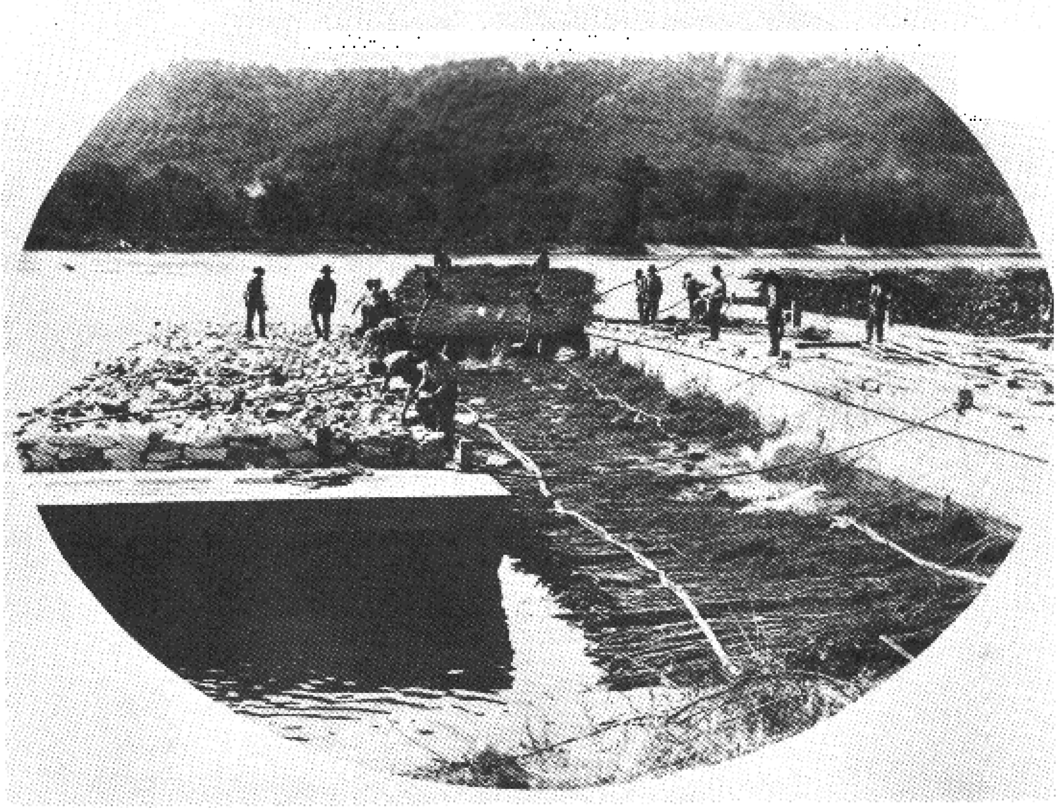
Wing dams proved to be an exceptionally economical method of river improvement. They were generally made of willow mats and crushed stone, both readily available along the whole Upper Mississippi Valley. Crews were able to lay several hundred feet of dam per day.

The first wing dams on the Upper Mississippi were built by the Corps fleet and personnel using hired labor, but after these early experiments developed the correct design, most of the rest were built by contractors, This would not have been possible without adoption of the 4½-foot channel project and the assurance it gave contractors that there would be enough future work to pay for building the equipment necessary to construct the dams. A wing dam fleet consisted of a steamboat, enough quarterboats for the crews as they moved up and down the river, and a variety of barges to haul stone and willow and on which to make the bmsh mats.

The extensive line of wing dams on the Upper Mississippi provided work for many small contractors rather than one or two large firms, as had been the case with previous improvements such as the Des Moines Rapids Canal, Some of the larger local contractors could and did make a business of Government work between 1878 and 1915, building wing dams up and down the river, but there was

The first experiments with wing and closing dams on the Upper Mississippi were carried out at Pig's Eye Island below St. Paul. The before and after sketches show the channel improvement resulting from the dams.





Willow mattresses were first placed into position along the dam, then sunk with a layer of rock. Rock had to be unloaded evenly to avoid tipping.

Each step of wing dam construction involved hard Labor, as seen in these photographs of work in the St. Paul area. Rock (up to six inches in diameter) had to be loaded on barges by hand; thousands of twelve-foot lengths of willow had to be tied in small bundles and than woven into mattresses.
—Minnesota Historical Society

room too for the small contractor with a boat and a crew to build a dam or two in his immediate area. Even for the very smallest contractors — a single individual — there was "winter work" to be contracted for. This consisted of repair work: holes in wing dams, breaks in closing dams and shore protections. Such repairs were hard to make in the summer when the river was high.

Bids for all of these jobs were advertised not only in the city papers at La Crosse and Winona, but in the small weeklies in the river villages such as Genoa, Stoddard, and Brownsville. In this way, nearly all of the money spent by the Government on the 4½-foot channel project went into the local economy through the pockets of numerous small contractors. This was one of the reasons why the Corps of Engineers in the Rock Island District was so well received and even well liked. The Corps seldom appeared here as it has in other places as an impersonal outside giant imposing ita will on a region.

The contracting firm which held the record for the amount of wing dam construction was the partnership of Albert Kirchner and Jamb Richtman of Fountain City, Wisconsin. These men obtained their first contract in 1878 just after the 4½-foot channel project was adopted. When World War I put an end to all appropriations in 1917, Kirchner was still operating as sole owner of the company.

Kirchner and Richtman assembled a fleet, consisting of a steamboat (or rather, a succesion of them, including such boats as the *Percy Swain*, long a well-known excursion boat between La Crosse and Alma, Wisconsin), three quarterboats, twa buildingboats, a light launch and 18 barges. A commissary boat selling soap, tobacco, and other sundries serviced this floating village.

Large barges about 100 feet long, 20 feet wide and 5 feet from deck to bottom hauled the broken rock and willow bundles (known as brush). Two small 30-foot barges called hoppers were used in weaving the willow into mats for the dams. The buildingboats were the largest of all. They were equipped with boilers and engines, steam and hand capstans. Their purpose was to hold the course along which the dam was to be built. They could propel themselves with lines anchored on shore and out in the river, and could pull barges of material into position.

Contracts for wing dams were usually let by the Rock Island District in the late fall or early winter, the work to be done the fallowing summer.[9] The contractor agreed to furnish "all boats, material, machinery, tools and other appliances necessary to do the work"[10] at points specified by the Corps.

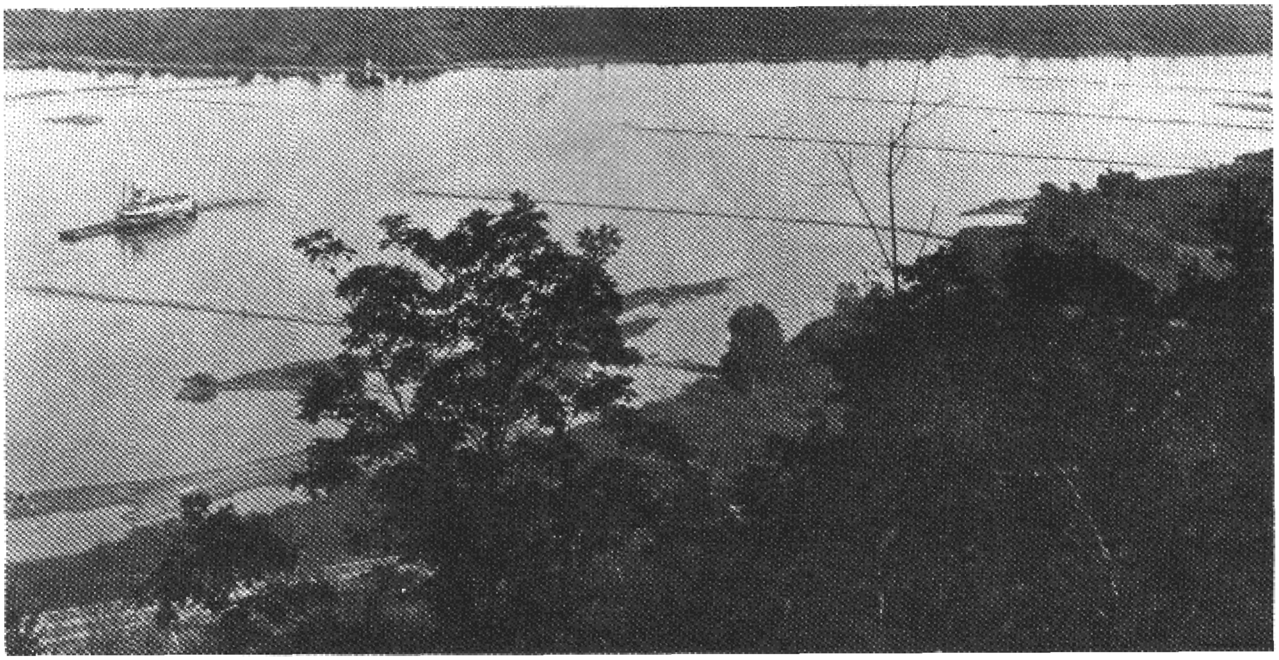
Material for the wing dams consisted of alternate layers of willow mat and crushed or broken atone. By terms of the Government contract the willow had to be recently cut, and trimmed so that the poles could be gathered into tight bundles or fascines 20 feet long and from 12 to 15 inches in diameter, tied with lath yarn or wire at 4-foot intervals.

These bundles were laid side by side on the hopper barge and lashed together by three or more willow poles on top and bottom (see illustration) to form a mat 12 feet long. The completed mat was pushed off the hopper, floated into position on the wing dam, and then sunk with rock from the stone barges.

Rock was obtained from the bluffs along the river, where it was as plentiful as the willow was in the bottoms. Some of the rock came from private sources and some from Government quarries that were opened and closed as the work progressed along the river. The rock had to meet a specification of 6 inches, cubed, or its equivalent, but not larger than 10 inches. Two-wheeled, one-horse carts brought the rock from the quarries to the barges. Rock had to be loaded uniformly on the barges to keep the barge level and so that Government inspectors could measure and mark down the amount of rock used. Thirty men worked on the stone barges, tossing rock off onto the willow mats.

A wing dam went up quickly. The bottom layer of brush was covered with rock from 6 inches thick at the upriver side to 18 inches on the downriver side. A second layer of bmsh was laid on this rock 10 or 15 feet further upstream than the lower layer, and covered with rock in the same proportions as the lower layer had been, Additional layers of bmsh were laid and covered with rock as needed to make the correct height, with each new layer placed an additional 2 feet upstream. The finished dam was high enough [generally 4 feet above low water) so that it3 top was above water except when the river was high.

Wing dams were serviceable and did what they were designed to do, but the long lines of rock and brush above water for much of the season were admittedly not beautiful. In 1914 a Mr. W.F.Daubenberger at McGregor, Iowa, complained to William



A row of wing darns during law water. Wing darns worked by forcing the current into a constricted main channel during low water, helping to scour the channel to a proper depth. The dams were submerged during high water. and did not impede the current.

Thompson, assistant engineer stationed at La Crosse:

With the automobile in such common use, people by the hundreds, within a radius of fifty miles, came in to spend a day or week on the river, Then they look across and see a pile of rocks sticking out of the water khat makes then think the armies of Europe were using it for a cemetery and were burying their dead there.[31]

It would still be some years, however, before the Rock Island District began to take tourism into account.

An improvement work as important as the wing dam was bank protection, or revetment. At the shore end of the wing dam, revetment was necessary to prevent the current from washing the shore away and rendering the dam useless. The completed wing dam would often deflect the current toward the opposite shore. Bank protection was needed at those places, too. Evsn straight sections of shoreline were often subject to wearing, and needed revetment.

Although most of the improvement in the 4½-foot project consisted of wing darns, closing dams similar to that built at the head of Pig's Eye Island in 1873 were also built. By closing off chutes, by-channels, and sloughs, closing dams helped direct the current into the main channel. Closing dams were far more dangerous to build than wing dams because of the currents produced by shutting off an entire channel.[12]

The decision where to place wing dams was made by District engineers who surveyed aut the line of each darn prior to the beginning of contract work. Wing dams were generally spaced 5/7 of the channel width apart. Where the river curved, dams were placed one-half a channel width apart on the concave side and full channel width apart on the convex side. The line of the dam pointed very slightly up stream 105 to 110 degrees in straight reaches, 100 to 102½ degrees in concave reaches, and from 90 to 100 degrees where the curve was convex. Dams on opposite sides of the river were arranged so that their axes met in mid-channel

By 1895 when Mackenzie left the Rock Island District, 100 miles of wing dams and 94 miles of shore protection had been built on the Upper Mississippi at a cost of $5,850,562. By 1895 most of the channel was navigable at low water.

Willow mats were used in the construction of wing dams until 1911. By then it was clear that the supply of available willow was giving out and not replacing itaelf as rapidly as it was being used up. The Rock Island District had anticipated this and had experimented, with willow nurseries and reforesting sandbars with willow cutting3 as early as 1881, but the annual floods and rapid currants prevented these from working out well. In 1911 successful experiments were made using lumber mats instead of willow. Any handy wood was used: maple, elm, oak, ash, cottonwood, and pine.[13]

Lumber mats were tried out on the section of the river between the Wisconsin River and Le Claim. Following successful experiments here they were used in the lower divisions of the District between Hannibal, Missouri, and the Missouri River.''' The cost of lumber mats compared favorably to willow, but they were not as flexible and did not follow the contour of the river bottom as well. Beginning in 1916 lumber mats were used exclusively for the remaining wing dam construction.

The Rock Island District also made several experiments with sand dams with some success. In 1896-97, 18 sand dams were built, a few of these entirely of sand but most of sand covered by a layer of brush and weighted down with rock. Sand for the dams was taken from the channel by the District suction dredge *Geyser*, and laid along the dam line beginning with the shore. Rock and willow barges on each side of the dam then covered the sand over. On one or two of these the District experimented with placing the willow bundles upright in hopes that the easily-rooted willow would sprout and grow, but this did not work.[15]

Both the willow and the sand wing dams proved to be amazingly permanent. They were often damaged from the ice and by passing boats, but they did not deteriorate much at all. The willow was submerged in the dams so it did not rot, and even today, after more than 100 years, pieces cut off of some of the willow will still float.

By the time authorization of the 6-foot channel project put an end to the 4½-foot project, a total of 12,323,067 cubic yards of brush had been put into dams and shore protections. Engineers and contractors had built 336.40 miles of wing and closing dams and 197.30 miles of shore protection. Total cost of the 4½-foot project from 1878 to 1905 was just over $11,000,000.[16]

## Other District Activities, 1877 to 1906

Although the 4½-foot channel constituted the major activity of the Rock Island District during these years, the Corps also engaged in several other projects related to navigation improvement. The period was marked by growing commerce and industry in the towns along the shore, and complicated by several major shifts in the patterns of water transportation. It was also a period of increasing responsibility for the Corps of Engineers. In 1890 the Corps was given specific authority to establish and enforce rules and regulations for the use of all navigable streams. From this has grown the Corps' responsibility for the entire inland waterway system.[17] In 1899 the Refuse Act, Section 13 of the Rivers and Harbor Bill, prohibited discharges except from public streets and sewers in liquid form into any navigable water of the United States without a permit from the Corps of Engineers. This Act has been seldom used until the past few years.

The appointment of the Mississippi River Commission in 1879 marked the beginning involvement of the Carps in flood control work, although "navigation improvement" remained the official justification until 1917. Prior to this, all authorized projects in the Rock Island District were limited strictly to navigation improvement, That continued to be the case; with the exception of several levee repair projects in 1894, District activities during this period continued to be concerned with navigation.

*Harbors.* Harbor improvements in the Rock Island District began as early as 1844 when Engineers had unsuccessfully attempted to improve the Dubuque harbor. Appropriations ran out before the work was completed, and several subsequent attempts met a similar fate. Finally, in 1880, Congress appropriated $40,000 for an ice harbor at Dubuque, where boats could winter safe from the effectsof the open river. Work was begun in 1882 and completed in 1885. This harbor was used not only by commercial vessels, but as a winter quarters for a large portion of the District fleet.

Other harbor improvements came slowly. The Corps of Engineers had been limited to single-purpose navigation projects, and a fine line divided those improvements which were necessary to commercial river traffic and those which primarily aided city interests or private groups of pleasure boaters. In fact the steamboat companies and the cities themselves had long been in disagreement over whose responsibility it was to improve harbors and waterfronts. One of the reasons for the steamboats' loss of commercial business during the last half of the 19th century was the lack of good waterfront and terminals for cargo. Steamboatmen wanted the towns to build such facilities while the towns felt the boat companies ought to do it. When the railroads came in and built such terminals themselves, they had an immediate commercial advantage over the boats.

Following the guidelines of "necessary to commercial river traffic," the Corps limited most of its harbor work to dredging sandbars which formed between towns and the main channel, building dams to serve as breakwaters, and deepening the harbors themselves so that larger boats were able to land. Improvements such as harbor enlargements or alterations of shape were left to city or private efforts. By 1911 the District had made major improvements to 22 harbors between St. Paul and Clarksville, Missouri, including most of the larger cities.

In the mid-1880's the Rock Island District designed and constructed two harbors of refuge in Lake Pepin, one at Stockholm, Wisconsin, in 1885, and one at Lake City, Minnesota, in 1887. Lake Pepin is a two- to three-mile wide section of the Mississippi between Red Wing and Read's Landing. There was no problem with currents from boats crossing the nearly slack water of this section, but the open area allowed winds to build up huge waves. These wreaked havoc on the long lumber and log rafts coming downriver from the northern forests. The rafts were frequently split up by such storms and the logs scattered for miles downriver, creating danger for the packetboats. At one time the District snagboat *General Barnard* encountered so many of these free logs that she had to lay up for the season.

The two harbors of refuge constructed by the District were designed to provide boats and rafts with a safe harbor from the sudden storms which frequented Lake Pepin. They consisted of long earth and stone piers built perpendicular to the shore which acted as breakwaters.

*Galena River Improvement.* Galena, Illinois, was one of the earliest and most ambitious towns on the Upper Mississippi River. Before the Civil War when the lead mines were thriving, more river traffic navigated the Galena River than arrived at St. Paul. But by 1866 increasing cultivation of farmland and a few years of neglect had combined to hasten the natural process of siltation to the point where the Galena River was impossible to navigate in low water and difficult at other times.

A preliminary survey of the Galena River with a view toward improvement was made by Major Farquhar in 1873. Congress authorized an improvement project in 1877, but work did not begin until 1880 when dredging produced a small channel between 35 and 100 feet wide and 4 feet deep, running 5½ miles from the mouth of the river to a point 1¾ miles below Galena.

No further appropriations were made. The Galena River project was in that borderline area between a navigable river (which was the Corps' responsibility) and unnavigable rivers (which were under jurisdiction of state or local authorities). There was doubt as to whether an improvement serving one city would constitute "general" navigation improvement.

Congress finally made a compromise. The Act of September 18, 1890, authorized the City of Galena to improve the Galena River from its mouth to a point 800 feet below the Custom House at Galena. Included in the authorization was a dam not more than 12 feet above low water and a lock not less than 280 by 62 feet. The act provided that after keeping the river open to a depth of 3 feet or more for one year, the city would receive $100,000 in Federal funds as partial cost of the improvement.

As a result of this agreement, the Rock Island District assumed control of the Galena Lock and Dam on March 12, 1894. Mackenzie appointed a lock master and two lock hands. Peak traffic though this lock was reached the following year when 471 boats and barges locked through carrying nearly 5,000 passengers and 2,000 tons of merchandise. By 1896 only 788 passengers on 234 boats passed through the lock. The only significant traffic that year consisted of 1,339,1200 board feet of lumber. The Part of Galena proved to be a victim of the railroad that had bridged the Mississippi at Dubuque, just to the north.

Operation of the Galena Lock and Dam was fundad under an indefinite annual appropriation beginning in 1898, but less and less traffic used the lock. In 1918 Congress recommended abandonment of the project. Both the lock and channel had reached a point where extensive repairs and dredging would be needed. Finally, the River and Harbor Act of September 22, 1922, directed that the project be abandoned. The District maintained the channel. during 1923, though there had been no traffic of record since 1921. The River and Harbor Act of March 3, 1925, directed removal of the dams in the Galena River. Today it is hard to imagine that Galena was ever one of the busy ports on the Upper Mississippi, and that boats of all sizes tied up at her waterfront.

*Surveys.* Apart from the Galena River survey of 1873 and a preliminary survey for an Illinois-Mississippi canal, the Rock Island District made only two surveys of Mississippi River tributaries during the kst quarter of the 19th century. Both were authorized by the River and Harbor Act of August 11, 1882, and were to determine if the rivers involved were navigable and worthy of improve ment.

The more important of these surveys was that of the Iowa River from its mouth to Wapello, a city of 1,000 where the Burlington, Cedar Rapids and Northern Rail Road crossed the river. Earlier in the century this and other small tributaries had been frequently navigated. Now, Mackenzie found that small boats still used the Iowa River during the high water season, but that it was not worthy of improvement.

The second survey made in the fall of 1882 was among the most unusual made by the Rock Island

District. This was the survey of the Pecatonica River from Argyle to Wayne, Wisconsin. Since April of 1882 a little steamboat called the *Success*, 50 by 14 feet with a one-foot draft, had been making semi-weekly trip3 on this stretch. Even though the *Success* was the only steamer ever to have been on this river, its presence made the stream technically navigable. The Pecatonica was so small that the *Success* had to stop periodically to open gates in the fences farmers had strung across it.

*Bridges.* Railroad and wagon bridges across navigable waters had been the responsibility of the Corps of Engineers since the Act of July 25, 1866. Problems with the Rock Island Bridge in 1856 together with a sudden increase in the number of bridges planned after the Civil War convinced Congress of the ned to regulate their construction so as to be fair to both navigation and railroad interests. Congress retained the authority to give or deny permits to build bridges, but the Carps of Engineers was given responsibility for determining the safest location, the spacing and size of the drawspan and raftspan, and later, when high bridges began to take the place of drawspan bridges, for determining the minimum height above high water.

The Act of July 5, 1884, further authorized the Secretary of War to require bridge companies to maintain adequate booms during the navigation season in order to facilitate navigation through the spans. The regulation of these booms became a Corps responsibility.

Booms were usually floating chains of logs or lumber cribs extending upstream from the drawspan piers to protect boats from drifting against the bridge. They were kept in place by anchoring them to pilings or to shore. The sheer booms at the Rock Island Bridge were kept in place by a system of rudders using the river current. Bridge companies had to maintain these booms in the channel until November E5 each year. That was when, by tradition, marine insurance ended, marking the official end of the navigation season.

Occasionally, a bridge proved to be such an obstruction to navigation that Congress ordered it removed or altered. Engineers then had the responsibility to see that those orders were carried out. The Hannibal Railroad Bridge, which had long been a dangerous annoyance to river traffic, was ordered to modify its structure by the River and Harbor Bill of July 5, 1884. After long litigation and delay, the Hannibal Bridge Company changed the location of it3 drawspan in accordance with the suggestions of District engineers.

The Corps of Engineers retained control over bridges across navigable waters until the mid-1960's, when the Coast Guard was assigned that duty.

*Improvements between St. Paul and Minneapolis.* Although Rock Island District performed little actual improvement on this short stretch of river, District engineers did much of the early planning for projects later completed by the St. Paul District.

Among the most important of these was repairing and stabilizing the Falls of St. Anthony. The upper crust over which the water flowed at the falls; was composed of hard limestone which resisted wearing. Underneath the thin crust was a layer of sandstone all the way dawn to the river bed, This sandstone layer wore away much mare rapidly than the limestone so that after a time the upper layer would lose its support and break off, moving the falls a few feat upstream. Erosion was rapid. By 1872 the falls had moved from 300 to 600 feet above its 1857 location. Left to continue, the falls would eventually be reduced to a long stretch of rapids, destroying not only the beauty of the falls but their waterpower potential, essential to a growing town and an expanding flour milling industry.

In 1872 the Chief of Engineers assigned the improvement of the falls to Macomb, who convened a Board of Engineers to atudy the problem on August 10, 1872.

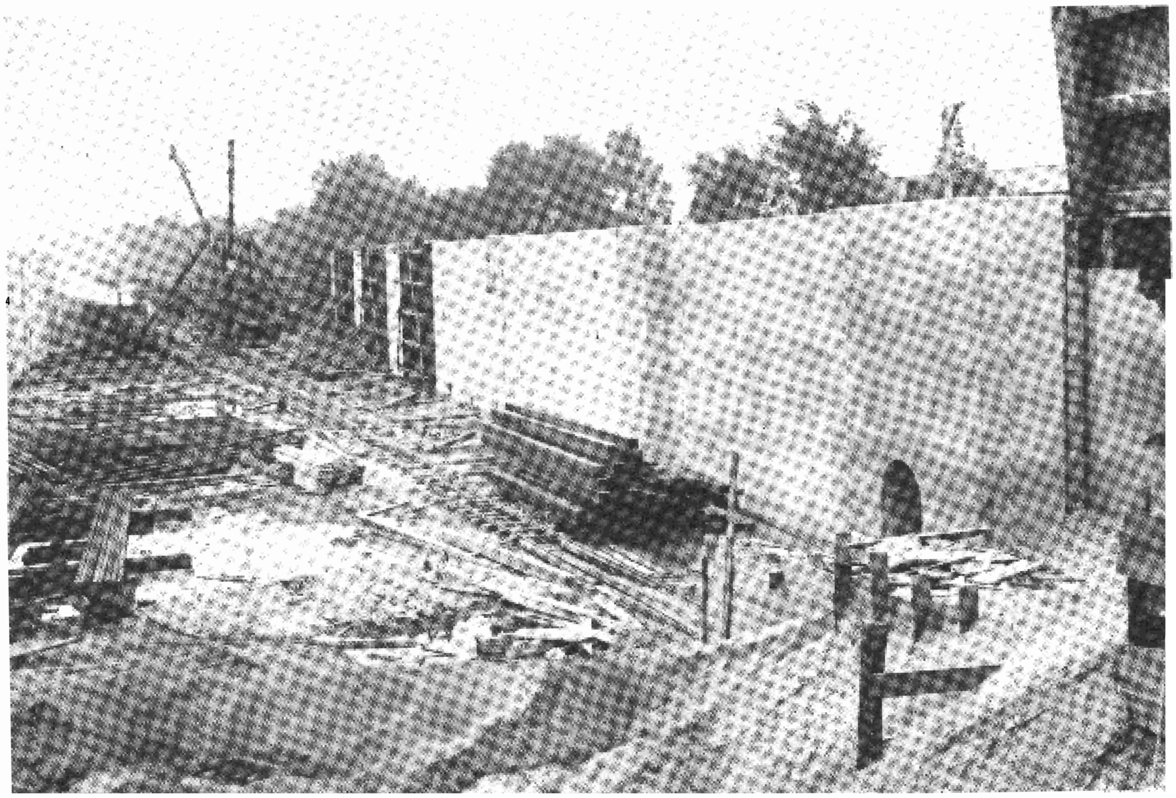
The natural wearing of the falls had been hastened in the late 1860's by a private group who began a tunnel at St. Anthony's Falls designed to run upstream as part of a hydroelectric project. The tunnel though the soft sandatone had reached a point under the foot of Nicolet Island late in 1869 when water entered the tunnel, washing out a large section and causing a cave-in. The tunnel further weakened the falls and the water rushing through the sandstone made the situation precarious.

J.L. Gillespie an assistant engineer of the Rock Island District stationed at the District sub-office in St. Paul, began construction of a wooden apron across Hennepin Island above the falls to divert; the water. The apron was in the process of completion when the work was reassigned to the St. Paul District on July 15, 1878.

During the 1891-92 seasons Mackenzie supervised the removal of a number of boulders between St. Paul and Minneapolis. The old head of navigation by act of Congress had been the steamboat landing below the Washington Avenue Bridge at Minneapolis, but now navigating to that paint was hard. Two seasons of removing boulders convinced Mackenzie that due to the swift current in this stretch, only a slack water system of locks and dams would bring permanent improvement.

On February 15, 1893, Chief of Engineers Brigadier General Thomas L. Casey ordered Mackenzie to prepare new and exact estimates for locks and dams between Minneapolis and St. Paul. Surveys and borings were made during the low water of 1893 and the plans and estimates drawn up the following winter. Mackenzie reported that to provide navigation to the Washington Avenue Bridge would require two locks and dams: No. 1 just above Minnehaha Creek and No. 2 at Meeker's Island, 1,000 feet below the C.M. and St. Paul Railway Bridge. The cost estimate was slightly over $1,150,000. Mackenzie reported that to obtain navigation all the way to the flour mills at Minneapolis would require two more locks and dams.[18]

Congress authorized Lock and Dam No. 2 in October 1894, and the Engineers made plans to lay the



The Moline Lock under construction. The successful experiments with structural concrete on the Illinois and Mississippi Canal determined that this lock be constructed in the same way.

lock foundation the following spring. However, a private group which owned rights-of-way on Meeker's Island dragged their feet, and by 1897 when the work in this section of the Mississippi was transferred to the St. Paul District, no work had been done, Lock and Dam No. 2 was completed in 1907, but it was drowned out ten years later by Lock and Dam No. I just above Minnehaha Creek. This dam, the Minneapolis "high darn" was built to generate electricity as well as to aid navigation. A second Lock and Dam No. 2 was completed at Hastings, Minnesota, in 1930, just prior to the 9-foot channel project.

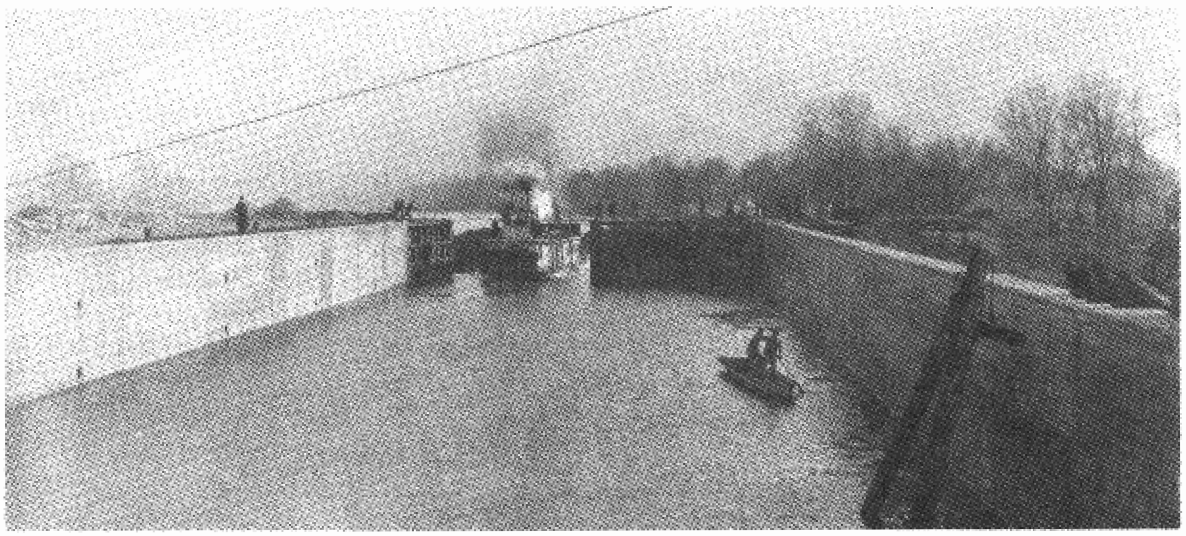
*The Moline* Lock. Improvements at the Rock Island Rapids had proved satisfactory while the rest of the channel was unimproved, but by 1900 the rest of the Upper Mississippi had been deepened to the point whwe the rapids again became an obstruction. At the same time, the growing farm equipment industry at Moline needed more adequate steamboat access to the Moline waterfront. Docking at Moline was especially hard for upstream boats. The Moline and Duck Creek chains had steeper slopes and swifter currents than anywhere else on the rapids, and boats had to cross both chains to reach Moline.

The River and Harbor bill in 1901 appropriated money for a survey for a lock at Moline and specified that the 'lock would use the new method of concrete construction which the Corps had developed for the Illinois and Mississippi Canal. The bill failed, but passed in 1902. That year, a Board of Engineers met in October to consider the new lock.

Congress did net authorize construction of the Moline Lock until the River and Harbor Bill of March 3, 1405. Although the Board of Engineers estimated the cost at $386,000 in their 1902 report, Congress appropriated only $100,000 to begin construction, and stipulated that the total cost not exceed $286,000.

Major Charles Riche became District Engineer at Rock Island in April 1905 and supervised the preparation of designs and drawings for the lock. He was well-prepared for this task, having come to Rock Island from the Second Chicago District

The U.S. steam launch *Emily* becomes the first boat to enter the new Moline Lock, begun as one of the final projects on the 4 1/2-foot channel and completed as one of the first on the 6-foot channel.



where he had supervised much of the construction of the Illinois and Mississippi Canal and had become familiar with the concrete construction techniques that had replaced stone construction on that project. In designing the Moline Lock, Riche relied on the advice of Meigs and other assistant engineers in the Rock Island Office. To supervise construction of the lock, Riche had a junior engineer, J.B. Bassett, temporarily transferred from the Northwest Division Office. Mr. Bassett opened a U.S. Engineer Office in Moline. By November 1905 plans were finished.

The Moline Lock project called for dredging a channel 250 feet wide with a 4-foot low water depth from Moline to the head of the Arsenal dike above the city, and a similar channel from Moline to the main channel by means of a lock and dam at the foot of Benham's Island opposite the city. The Moline Lock project was designed to improve 3 miles of the 14-mile Rock Island Rapids.

Bids were advertised and on March 31, 1906, a contract was signed with the Dravo Construction Company of Pittsburgh, to be completed on or before April 1, 1908. The lock chamber was to be 325 by 80 feet. Original authorization called for a 4-foot channel depth with 5 feet in the lock chamber, but in September of 1905, anticipating the coming 6-foot channel project, the depth was increased to 6 feet. The lock was to have concrete walls and wooden gates, operated by electricity. The dam and all back fill were to be built by the Corps using hired labor.

Work went smoothly on all aspects of construction, aside from a stray shot now and then from the Arsenal test range nearby. Though not completely finished, the Moline Lock opened for traffic on December 23, 1907. In January 1908 the Rock Island District officially accepted the lock from the contractor.

Most of the lock usage during 1908 came from District boats transporting supplies. In the spring of 1909 the ferry steamer *B.B.* began using the lock for service between Moline and Bettendorf, Iowa, and by May the lockmaster recorded 612 lockages with 17,308 passengers. Only three moths later, in August, the Moline Lock recorded it3 peak use: 1,146 lockages with 18,998 passengers, but a corn-mercial freight of only 182 tons. The Moline Lack suffered from bad timing, being finished just as a long decline in river traffic set in. It did have one year of glory, however. The lockages in June, July, and August of 1909 each surpassed the total so far for any single month of the famous Soo Locks. In fact, these three months probably set a record greater than any lock in the world up to that time.[19]

## Notes

Chapter 4

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2. *Official Report of the Proceedings of the Mississippi River Improvement Convention Held at St. Louis, Mo., 1881* (St. Louis: Great Western Printing Company, 1881), p. 107.

3. Material here and on the next three pages is from the *Annual Reports* of 1878-79.

4. J.D. DuShane to Col. W.R. King, August 22, 1896, File 1653, Vol. 43, Press Copies of Letters Sent ("General Letter Books"), RG77, NA.

5. *Annual Report*, 1875, II, pp. 455-67.

6. *Annual Report*, 1876, Appendix T, p. 6.

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12. Hill, p. 287.

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14. Samuel Edwards and Robert Iakisch, "Uses of Plank or Lumber Apron for Shore Protection on the Upper Mississippi River between the Wisconsin River and Le Claire, Iowa," *Professional Memoirs*, VII (1916), p. 390.

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